REMARKS

By the present amendment, claims 1-4, 6, 8-10, and 15-16 are pending in the application. Claims 1-4 are independent claims.

Restriction Requirement

The Office Action withdrew method claims 17 to 22 from consideration due to a restriction requirement.

By the present amendment withdrawn method claims 17 to 22 have been canceled without prejudice to the filing of a divisional application directed to the subject matter of claims 17 to 22.

§112,¶1

In the Office Action, claims 1 to 4, 6, 8 to 10 and 15-16 were rejected under 35U.S.C.§112, first paragraph, as failing to comply with the written description requirement.

The Office Action maintains that the expressions "not more than 0.5% Cr" and "not more than 0.5% Mo" in claims 1 to 4 are not supported by the specification as originally filed.

The Office Action maintains that Cr in an amount greater than 0% and less than 0.005% is new matter and that Mo in an amount greater than 0% and less than 0.1% is new matter.

This rejection is respectfully traversed.

The arguments against the rejection of claims 1 to 4, 6, 8 to 10 and 15-16 under 35 U.S.C. §112, first paragraph, are repeated in order to preserve the issue for appeal.

The Office Action recognizes that 0% Cr and 0% Mo is disclosed in the specification because Cr and Mo are disclosed as optional chemical elements in the steel composition of the steel pipe of the present invention.

The Office Action also recognizes that 0.005 to 0.5% Cr and 0.1 to 0.5% Mo are disclosed in the specification.

The Office Action takes a very narrow view that the specification only mathematically recites 0% and 0.005 to 0.5% Cr and 0% and 0.1 to 0.5% Mo.

The Office Action ignores the principle that the disclosure of the specification is directed to one skilled in the art and the disclosure of the specification is understood as it is understood by one skilled in the art.

The specification makes the following disclosure with respect to the optional Cr and Mo additions to the steel composition of the steel pipe of the present invention at page 8, lines 15 to 26.

> Cu, Cr, Mo and Ni are solid solution hardening components that enhance strength by dissolving in martensite crystals and thus preventing dislocations from passing through the dissolved components. Note that Cr and Mo function also as precipitation hardening components. Those components, thought they contribute to the enhancement of strength, cause the cost to increase and, moreover, <u>form segregated inclusions when they are excessively added</u>. Therefore, their **appropriate** amounts are 0.005 to 0.050% Nb, 0.005 to 0.07% V, 0.005 to 0.5% Cu, 0.005 to 0.5% Cr, 0.1 to 0.5% Mo and 0.1 to 0.5% Ni. (Emphasis added).

Disclosing that a minimum of 0.005% Cr and a minimum of 0.1% Mo to obtain a beneficial result from optional **appropriate** Cr or optional **appropriate** Mo does not **exclude** the applicants from claiming 0 to 0.5% Cr and 0 to 0.5% Mo. The applicants are disclosing that greater than 0% to less than 0.005% Cr and greater than 0% to less than 0.1% Mo are ineffective or the same as 0% optional.

The specification clearly is teaching one skilled in the art that a minimum of 0.005% Cr and a minimum of 0.1% Mo are required in order to have their beneficial effects of enhancing strength and providing precipitation hardening. The specification is also clearly teaching that greater than 0.5% Cr and greater than 0.5% Mo are not desired and detrimental.

One skilled in the art would clearly understand the specification discloses that for the optional Cr or optional Mo, that greater than 0% but less than 0.005% Cr has no beneficial effect or that greater than 0% but less than 0.1% Mo has no beneficial effect.

Applicants maintain that the specification clearly teaches one skilled in the art that if the optional Cr or optional Mo is added to the steel composition of the steel pipe of the present invention, greater than 0% Cr but less than 0.005% Cr has no beneficial effect or greater than 0% Mo but less than 0.1% Mo has no beneficial effect. These ranges are clearly disclosed in the specification as within the possession of the inventors at the time the application was filed.

The CCPA has made clear in *In Re Dinh-Nguyen and Stenhagen* 181 USPQ 46, 47 (CCPA 1974) that

> Any assertion by the Patent Office that the enabling disclosure is not commensurate in scope with the protection sought must be supported by evidence or reasoning substantiating the doubts so expressed.

The Office Action has provided no evidence or reasoning substantiating that the specification has not disclosed to one skilled in the art reading the specification information with respect to greater than 0% to less than 0.005% to Cr or with respect to greater than 0% to less than 0.1% Mo or that information with respect to these ranges was not in the possession of the inventors.

The CCPA has also made clear in In re Dinh-Nguyen and Stenhagen that is not the function of the claims to specifically exclude ineffective reactant proportions. See, 181 USPQ 46,48 (CCPA 1974).

> Disclosure in the *specification* sufficient to enable practice of the invention by one skilled in the art, taking into consideration obvious modifications of the reactant ratios of specific examples, is all that is required. It is not a function of the *claims* to specifically exclude either possible inoperative substances or ineffective reactant proportions.

There Is Enablement

The specification has clearly disclosed that greater than 0% to less than 0.005% Cr and greater than 0% to less than 0.1% Mo are **inappropriate** because they are essentially the same as 0%.

One skilled in the art could easily added to the steel composition greater than 0% to less than 0.005% Cr and greater than 0% to less than 0.1% Mo without undue experimentation. The applicants have provided a high degree of enablement to the art by advising one skilled in the art that to the applicant's knowledge, if optional Cr or optional Mo is added to the steel composition, it is ineffective in obtaining the beneficial result of the optional 0.005 to 0.5% Cr and 0.1 to 0.5% Mo.

The specification discloses very useful information to one skilled in the art regarding greater than 0% to less than 0.005% Cr and greater than 0% to less than 0.1 to Mo. The disclosure of the specification is directed to one skilled in the art.

The Examiner's Position

Invites Infringers

The Examiner's position is that the applicants are only entitled to claim 0% Cr (optional Cr) and 0.005 to 0.5% Cr and likewise the applicants are only entitled to claim 0% Mo and 0.1 to 0.5% Mo.

There is good reason why the CCPA made clear in the above cited In re Dinh-Nyugen and Stenhagen, that it is not the function of the claim to exclude ineffective reactant proportions. The Examiner's position is an invitation to infringers based upon the applicants own disclosure in the specification. The potential infringer only has to read the applicants' specification in an issued patent to be informed that Cr and Mo are optional in the steel composition, be advised that greater than 0% Cr to less than 0.005% Cr and greater than 0% Mo to less than 0.1% Mo are ineffective and thus, the same as optional. This is the clear

disclosure of the specification. The potential infringer would then see the claims only claim 0% Cr and 0.005 to 0.5% Cr and 0% Mo and 0.1 to 0.5% Mo. The potential infringer has been taught by the applicants own specification how to avoid infringement, i.e., add Cr and/or Mo in the ineffective amounts Cr and/or Mo which are only optional and infringement of the claims is avoided because of the gaps in the claims.

The Examiner's position is essentially that the applicants are required to disclose in the specification to a potential infringer how to avoid infringement of the claims to the applicants' invention. The disclosure of the specification is clear to one skilled in the art and the gap in the claims would be clear to one skilled in the art.

The CCPA, in reversing the Board of Appeals has made very clear in In re Goffe, 191 USPQ 429 (CCPA 1976), that the above situation is not permissible. The CCPA in In re Goffe, 191 USPQ at 431 stated

> For all practical purposes, the board would limit appellant to claims involving the specific materials disclosed in examples, so that a competitor seeking to avoid infringing the claims would merely have to follow the disclosure in the subsequently-issued patent to find a substitute. However, to provide effective incentives, claims must adequately protect inventors. To demand that the first to disclose shall limit his claims to what he has found will work or to materials which meet the guidelines specified for "preferred" materials in a process such as the one herein involved would not serve the constitutional purpose of promoting progress in the useful arts. (Emphasis added).

Summary

It is submitted that the claim limitations "not more than 0.5% Cr" and "not more than 0.5% Mo" are supported by the disclosure of the specification as originally filed. Claims must adequately protect the inventors.

It is therefore respectfully requested that the rejection under 35 U.S.C. §112, first paragraph, be withdrawn.

§103

In the Office Action, claims 1, 6 and 8 to 10 were rejected under 35 U.S.C. §103(a) as being unpatentable over Japan No. 6-179945.

Claims 1 to 4, 6, 8 to 10 and 15- 16 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,374, 322 to Okada *et al.*

These rejections are respectfully traversed.

THE PRESENT INVENTION

The present invention is directed to the following combination of features.

1. A water quenched steel pipe having a defined composition, wherein water quenched means cooled at a cooling rate of 6,000°C/min or higher with cooling water having a temperature of 35°C or lower.

2. A steel composition for the pipe which includes 0.5 to 1.60% Mn wherein the presence of Cr and Mo in the steel composition is optional. That is the steel composition of the pipe can contain 0% Cr and 0% Mo. If Cr is present in the steel composition of the pipe of the present invention, the maximum Cr permitted is 0.5%. If Mo is present in the steel composition of the pipe of the present invention, the maximum Mo permitted is 0.5%.

3. The present invention has a low YR (yield ratio) in combination with a very high TS (tensile strength). The minimum tensile strength of independent claims 1 to 4 and 17 is as follows.

claim 1	-	1700 MPa	=	173.9 kgf/mm^2
claim 2	-	1800 MPa	=	183.5 kgf/mm^2
claim 3	-	1900 MPa	=	193.7 kgf/mm^2

claim 4	-	2000 MPa	=	203.9 kgf/mm^2
claim 17	-	1700 MPa	=	173.9 kgf/mm^2

The conversion factor of 1 kgf/mm^2 = 9. 81 MPa or MPa/9.81 = kgf/mm^2 was used.

4. The very high TS of the present invention is the result of the claimed chemical composition of the steel of the pipe as set forth in independent claims 1 to 4 in combination with heat treating of the pipe followed by water quenching at 6,000°C/min or higher. Water quenching at 6,000°C/min or higher is particularly important. Induction heating is a disclosed preferred heat treatment. The cooling rate of water quenching is 100°C/sec (6,000°C/min) or higher, which results in the very high TS and low YR. Specification, page 9, line 37 to page 10, line 3.

The yield ratio (YR) of the claims is at 0.1% proof stress. Fig. 2 of the specification of the present application illustrates that water cooling at 100°C/sec (6,000°C/min) or greater has a very significant effect on yield ratio (YR) at 0.1% -proof stress, whereas the cooling rate at 0.2% proof stress is not a significant consideration. Fig. 3 of the specification of the present application illustrates that a cooling water temperature of 35°C or lower is significant for obtaining low YR (%) at 0.1% -proof stress, whereas cooling water temperature is not significant with respect to YR(%) at 0.2% -proof stress.

The Examples of the present invention at Table 2, page 14 of the specification disclose water quenching cooling rates of 150 to 200°C/sec (9,000 to 12,000°C/min).

The water quenching causes an instantaneous transformation from austenite to martensite and the dislocation density in the martensite structure increases drastically. Specification, page 9, lines 14-19.

The high dislocation density caused by the water quenching lowers the yield point (YS) while a higher TS is maintained. Specification, page 9, lines 28-36. The dislocation density of the present invention is 10^{10} - $10^{14}/mm^{-2}$.

5. The high tensile strength (TS) defined in independent claims 1 to 4 is the result of water quenching of the heat treated steel pipe having the steel composition defined in independent claims 1 to 4.

The water quenching of the present invention results in the high dislocation density of the present invention, 10^{10} - $10^{14}/mm^{-2}$, which is set forth in dependent claim 6. The high dislocation density of the present invention results in the high tensile strength (TS) of the present invention.

6. The cited prior art, JP 6-179945 ("JP '945") and U.S. Patent No. 5,374,322 ("US '322) does not disclose or suggest the steel pipe composition of claims 1 to 4.

7. The cited prior art, JP '945 and US '322, teaches air cooling, not water quenching. Air cooling provides a cooling rate of at most a few 100°C/min. Water quenching, in accordance with the present invention, provides a cooling rate of 6,000°C/min (100°C/sec) or higher. Specification, page 9, line 37 to page 10, line 3.

8. The cited prior art, JP '945 and US '322, does not disclose or suggest a steel pipe which has, <u>in combination</u>, (i) a water quenched steel pipe having the steel composition defined in independent claims 1 to 4 <u>and</u> (ii) a tensile strength (TS) of 1700 MPa (173.9 kgf/mm^2) or higher.

<u>CLARIFICATIONS - JP '945</u>

The Japanese patent attorneys handling this case provided the following clarifications with respect to the disclosure of Japan No. 6-179945.

Table 1

Examples 1, 2 and 3 of Table 1 of JP '945 appearing at page 5 [0027] of JP '945 are comparative examples. Examples 4 to 18 of Table 1 of JP '945 are examples of the technology disclosed in JP '945. This also applies to Table 2 at page 6 [0028] of JP '945.

This information was not expressly included in the computer English translation of JP '945 provided by the PTO.

Table 2

The computer English translation of JP '945 provided by the PTO did not translate the headings of the columns of Table 2 (page 6 [0028]) of JP '945. The columns of Table 2 (page 6 [0028]) of JP '945 are directed to the following parameters.

Col. 1 - Example number.

Col. 2 - Hot rolling finishing temperature (°C).

Col. 3 - Coiling temperature (°C).

Col. 4 - Heat treatment temperature for ERW pipe.

Col. 5 - Cold working ratio (%).

Col. 6 - Final heat treatment for the cold worked pipe.

Col. 7 - Tensile strength (TS) of a steel plate prior to being manufactured into a pipe. Thus, in Example 1, Col. 7 of Table 2 discloses that a steel plate has a tensile strength (TS) of 125 kgf/mm^2 prior to being manufactured into a steel pipe.

Col. 8 - Tensile strength (TS) of the final steel pipe product. Thus, in Example 1, Col. 8 of Table 2 discloses that the final steel pipe product has a tensile strength of 152 kgf/mm^2.

Col. 9 - Elongation of the final steel pipe product (%).

Col. 10- Yield ratio (YR) of the final steel pipe product. Thus, in Example 1, Col. 10 of Table 2 discloses that the final Steel pipe product has a yield ratio (YR) of 0.80.

[0024]

In paragraph [0024] of JP '945, the cooling rate parameter is 10-150°C/min. The computer English translation states "10-150-degree-C/. The computer English translation does not translate the parameter as °C/min which appears in the original Japanese.

PATENTABILITY OVER PRIOR ART

Japan No. 6-179945

JP '945 has a big difference in the Mn content and the cooling rate in the steel production. The present invention defines the Mn content to be 0.5 - 1.6%. On the other hand, JP '945 defines the Mn content to be 2.0 - 3.0%. JP '945 clearly discloses that Mn must be maintained at the lower limit of 2.0% for increasing tensile strength and elongation.

Because the higher Mn content in JP '945 the cooling rate (critical cooling rate) can be lowered, i.e., relatively slow cooling, for obtaining the martensite structure.

In other words, the feature of JP '945 is to add a higher amount of Mn, in addition to adding Cr and Mo as indispensable elements for forming martensite by means of a slow cooling rate. On the other hand, the present invention targets to rapidly cool the steel for forming martensite to secure high strength and to enhance dislocation density in the metallic structure by means of rapid transformation for obtaining the low yield ratio. The present invention does not require a high amount of Mn compared with the high amount of Mn in JP '945 because of rapid cooling in the present invention.

JP '945 is directed to a normalized, i.e., air cooled, steel pipe. The present invention is directed to a water quenched steel pipe.

There is no overlap in composition. JP '945 has a steel composition containing 2.0 to 3.0 wt% (or mass %) Mn. The steel composition of the present invention contains 0.5 to 1.60 mass % Mn. Therefore, the lowest Mn of JP '945 (2.0%) is 25% greater

than the highest Mn of the present invention (1.60%). A 25% difference between lowest and highest is not insignificant. A 25% difference is not prima facie obvious. JP '945 cannot obtain a tensile strength of 1700 MPa using the composition of the steel claimed in independent claims 1 to 4.

The only example of JP '945 to attain a tensile strength of 1700 MPa (173.9 kgf/mm^2) or more (claim 1 of the present application) is Example 11 which has a tensile strength of 180 kgf/mm^2. Example 11 of JP '945 discloses a steel composition containing 2.50% Mn which is 56% greater than the maximum Mn (1.60%) of the present invention. Example 11 has a steel composition containing 1.0% Mo which is 100% greater than the maximum Mo (0.5%) of the present invention.

Thus, JP '945 requires a steel composition which is significantly different than the claimed steel composition of the present invention in order for JP '945 to attain a tensile strength of 1700 MPa (173.9 kgf/mm^2) required by claim 1 in accordance with the present invention.

JP '945 is significantly different than the present invention.

Composition and Cooling

JP '945 teaches a steel pipe which has a steel composition which contains 2.0 - 3.0 wt% (or mass %) Mn. See claims 1, 2 and [0013] of JP '945. The computer English translation of [0013] of JP '945 discloses that Mn is required in an amount of at least 2.0% or more in order to obtain a good reinforcement and ductility balance, raise the reinforcement and to secure elongation. In JP '945, claim 1 and the English abstract disclose a tensile strength (TS) of 150 to 180 kgf/mm^2, but this tensile strength is disclosed in combination with Mn in the range of 2.0 to 3.0 wt %, which is outside the Mn range of the present invention (0.5 to 1.60 mass % Mn).

In the computer translation of JP '945, [0006] is the Means For Solving The Problem. This is followed by [0007] of the computer translation which discloses 2.0 - 3.0 wt% (mass%) Mn, a Cr - Mo system and the organization of martensite and banite by normalizing. The English Abstract of JP '945 discloses the Title of JP '945 as "Chromium - molybdenum system, electric welded steel pipe ...". The English Abstract of JP '945 discloses 2.0 - 3.0% Mn and a structure of martensite and banite obtained by normalizing.

It is thus clear that 2.0 to 3.0% Mn is essential to the technology of JP '945. The present invention, defined in independent claims 1 to 4, is directed to 0.5 - 1.60% Mn.

JP '945 is directed to a Cr - Mo system. This technology of JP '945 is different from the present invention where Cr and Mo are arbitrary components of the steel composition.

JP '945 teaches normalizing or air cooling of the steel. See discussion above. The art understands normalizing to mean annealing followed by air cooling, particularly cooling in still air or natural cooling.

In the present invention, there is water quenching of the heat treated steel pipe. Water quenching means a cooling rate of about 100°C/sec (6,000°C/min) or more which is very different from normalizing or air cooling which at most has a cooling rate of a few 100°C/min. The Examples of the present invention at Table 2, page 14 of the specification disclose water quenching cooling rates of 150 to 200°C/sec (9,000 - 12,000°C/min). The water quenching of the present invention uses cooling water having a temperature of 35°C or lower. As previously discussed, the water quenching of the present invention is directly related to the very high tensile strength (TS) and low YR of the present invention. The water quenching of the present invention results in the high dislocation density of 10^{10} to 10^{14}/mm^{-2}

which is directly related to very high tensile strength (TS) and low yield rate (YR). See again specification page 9, line 14 to page 10, line 9.

Comparative Examples of JP '945

Comparative Examples 1 to 3 at Tables 1 and 2 of JP '945 disclose the following.

	Mn	Mo	Cr	TS
Ex. 1	1.30	2.0	0.5	152 kgf/mm^2
Ex. 2	1.60	0.5	2	155 kgf/mm^2
Ex. 3	1.60	1.5	0.0	155 kgf/mm^2

Comparative Examples 1 and 3 of JP '945 disclose 2.0% Mo or 1.5% Mo. This is outside the maximum permitted Mo of 0.5% specified in independent claims 1 to 4 and 17. Comparative Example 2 of JP '945 discloses 2% Cr. This is outside the maximum permitted Cr of 0.5% specified in independent claims 1 to 4.

Therefore, Comparative Examples 1, 2 and 3 of JP '945 do not disclose or suggest the steel pipe composition of the present invention defined in independent claims 1 to 4.

The minimum tensile strength (TS) claimed, in accordance with the present invention, is 173.9 kgf/mm^2 (1700 MPa) claimed in independent claim 1. Comparative Examples 1, 2 and 3 of JP '945 disclose tensile strengths of 152, 155 and 155 kgf/mm^2.

Comparative Examples 1, 2 and 3 of JP '945 do not disclose or suggest the steel composition of the present invention or a minimum tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) required by the present invention.

Examples of JP '945

The Examples of the technology of JP '945 are Examples 4 to 18 of Tables 1 and 2. All of Examples 4 to 18 of Tables 1 and 2 of JP '945 disclose Mn in a range of 2.0 to 3.0% Mn. This is outside the range of Mn claimed for the steel composition of independent claims 1 to 4 which claim 0.5 to 1.60 % Mn.

Page 7, lines 30-32 of the specification discloses that when the upper limit of the Mn range of the present invention is exceeded, baking cracks and segregation are undesirably caused.

Therefore, Examples 4 to 18 of the technology of JP '945 do not disclose or suggest the steel pipe composition of the present invention defined in independent claims 1 to 4.

All of Examples 4 to 18 of Tables 1 and 2 of JP '945 disclose a tensile strength (TS) of less than 173.9 kgf/mm^2 (1700 MPa) except Example 11 which discloses a tensile strength (TS) of 180 kgf/mm^2.

However, the composition of Example 11 of JP '945 contains 2.50% Mn and 1.0% Mo which are outside the range of 0.5 to 1.60% Mn and not more than 0.5% Mo claimed by independent claims 1 to 4.

JP '945 does not disclose or suggest a steel pipe with the composition in accordance with the present invention having a tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) or greater. JP '945 does not disclose or suggest how to make a steel pipe with the composition defined in independent claims 1 to 4 having a tensile strength (TS) of 173.9 kgf/mm^2 (1790 MPa) or greater because JP '945 does not disclose or suggest water quenching of a heat treated steel pipe having a steel composition in accordance with the

present invention. JP '945 teaches normalizing or air cooling a heat treated steel pipe which does not have the defined composition of the present invention.

Note, Example 11 of JP '945 does not disclose or suggest a tensile strength of 183.5 kgf/mm^2 or greater (claim 2 - 1800 MPa); a tensile strength of 193.7 kgf/mm^2 or greater (claim 3 - 1900 MPa) or a tensile strength of 203.9 kgf/mm^2 (claim 4 - 2000 MPa).

JP '945 does not disclose or suggest the very high dislocation density of 10^{10} to $10^{14}/mm^{-2}$ of dependent claim 6. The very high dislocation density of the present invention is the result of water quenching and the very high dislocation density of the present invention results in the very high tensile strength (TS) and low yield ratio (YR) of the present invention. JP '945 teaches normalizing of a heat treated steel pipe.

U.S. Patent No. 5,374,322

US '322 has a big difference in the Cr content and the cooling rate in the steel production. The present invention defines the Cr content as less than 0.5%. On the other hand, US '322 defines the Cr content as 1.0 - 3.5%. US '322 patent clearly discloses that Cr is effective for improving hardenability and toughness, and the incorporation of Cr is also effective to suppress excess softening during tempering.

US '322 further discloses that Cr is essential to US '322 in which a long pipe is quenched by cooling at a cooling rate corresponding to that of air cooling with distortions caused by quenching being greatly suppressed compared with those causes by water quenching. US '322 discloses that then the Cr content is less than 1.0%, improvements in hardenability, toughness and softening resistance are not sufficient. This means that US '322 must contain a large amount of Cr to secure hardenability, toughness and softening resistance.

In '322 patent, the higher Cr content lowers the cooling rate (critical cooling rate), i.e., relatively slow cooling, for obtaining the martensite structure. In other words, the feature of US '322 is to add a higher amount of Cr for forming martensite by means of slow cooling rate. On the other hand, the present invention targets to rapidly cool the steel for forming martensite to secure high strength and to enhance dislocation density in the metallic structure by means of a rapid transformation for obtaining a low yield ratio. The present invention does not use the high amount of Cr compared with the high amount of Cr in US '322 because of rapid cooling.

Fig. 1 of Attachment A hereto shows each alloying elements affect on the critical cooling rate. This Fig. 1 is from the Technical Publication "Iron & Steel Materials" (1981, p 242).

As hereinafter discussed in detail, US '322 teaches that Cr (1.0 to 3.5%) is <u>essential</u> to the technology of US '322 in combination with <u>air cooling</u>. See Col. 6, lines 40-44.

The steel pipe of the present invention is <u>water quenched</u> and <u>Cr is optional</u> in the steel composition of the present invention. If Cr is present in the steel composition of the present invention, the maximum Cr is 0.5%.

The minimum, essential Cr of US '322 (1.0%) is 100% greater than the maximum Cr (0.5%) in the steel composition of the present invention. <u>A 100% difference is not prima facie obvious. US '322 cannot obtain a tensile strength of 1700 MPa using the composition of the present invention</u>.

Cooling - US '322

US '322 uses the term "water quenching" at Col. 9, lines 45-56 in a manner that is not the ordinary and accustomed meaning as understood by one skilled in the art. US '322 states at Col. 9, lines 45-56:

> In typical procedures of the method of the present invention, quenching, i.e., cooling is carried out using air as a cooling medium. If necessary, a mist, shower, forced air, or combinations thereof may be used to carry out quenching. When a cooling medium is mainly comprised of water, i.e., when water quenching is employed, quenching cracks and bends easily occur. However, when such defects can be recovered by straightening, <u>water quenching is not excluded from the present invention as long as the bainite index or the cooling rate R is within the range of the present invention</u>.

The Examiner has cited this disclosure of US '322 in the Office Action mailed June 27, 2007 at page 8, lines 1-2 for showing that US '322 does not exclude "water quenching". As we have discussed in previous responses, the overall teaching of US '322 is "air cooling" and US '322 teaches against "water quenching".

The use of the term "water quenching" at Col. 9, lines 45-56 in US '322 is not the use of the term "water quenching" in its ordinary and accustomed meaning as understood by one skilled in the art. One skilled in the art understands "water quenching" to mean very rapid cooling. In Col. 9, lines 45-56 of US '322, "water quenching" means a cooling process which employs water but has a cooling rate which corresponds to an "air cooling" cooling rate. See, e.g., US '322 at Col. 6, lines 37-44 which reads:

> Chromium is effective for improving hardenability as well as toughness. The incorporation of Cr is also effective to suppress excess softening during tempering. Like Mn, Cr is essential to the present invention in which a long pipe is <u>quenched by cooling at a cooling rate corresponding to that of air cooling</u>, with distortions caused by quenching being greatly suppressed compared with those caused by water quenching.

The use of the term "water quenching" at Col. 9, lines 45-56 of US '322 requires that the "banite index" or the "cooling rate R" be within the range specified by US '322.

In US '322, R is a cooling rate in °C/min. See US '322 at Col. 4, line 40.

The use of the parameter °C/min to define the cooling rate R of US '322 is a strong teaching that US '322 is only directed to cooling rates which correspond to "air cooling" whether or not water may be used in the cooling process.

Bainite Index

The "bainite index" of the steel composition in US '322 is 0-50%. See Col. 4, lines 33-34.

When the steel of US '322 contains the Mo and Ti (required by the present invention), Col. 4, lines 48-50 defines the bainite index in (%) as follows.

$$(\%) = -290C + 43Si - 48Mn - 58Cr - 13Ni - 63Mo - 0.416R + 317.$$

R is the cooling rate in °C/min. When the minimum cooling rate of the present invention of 6,000 °C/min is inserted into the "bainite index" equation of US '322 as R (cooling rate) [-(0.416 x 6,000)], a very large negative number of " - 2496" would be obtained. It is readily apparent that the remaining components of the "bainite index" equation of US '322 would not significantly change -2496% as compared to 0%. For example, minimum Cr and minimum Mn in US '322 are both 1.0% (Col. 4, lines 28-29) which results in a significant reduction of -317 and the maximum Si of 0.70% does not result in a significant increase. All other components of the "bainite index" equation of US '322 would cause the bainite index to become more negative.

It is thus readily apparent that the minimum cooling rate of 6,000 °C/min required by the present invention would result in a very large negative number for the "bainite index" of US '322, i.e., approximately -2496%, which is very much lower than the

lower limit of 0% for the bainite index specified in US '322 and very much lower than the teachings of US '322. US '322 states at Col. 9, lines 38-44:

> When the bainite index is below zero, it means that the cooling rate is higher than the critical cooling rate to achieve 100% martensite. Such an <u>excessively high cooling rate</u> causes an easy occurrence of large bends and cracking during quenching, and delayed cracking easily occurs during straightening. Furthermore, the yield ratio inevitably increases.

US '322 teaches that a "bainite index" of below zero is the result of an "<u>excessively high cooling rate</u>". The minimum cooling rate of 6,000 °C/min of the present invention which results in a US '322 "bainite index" on the order of a negative number of approximately -2496% is very far outside the technology disclosed, suggested by or contemplated by US '322. The lowest bainite index disclosed in the Examples of US '322 is -82% for Steel B10 of Table 7 which is a comparative example and Col. 18, lines 10-12 discloses "Although not indicated in Table 7, quenching cracks occurred for the conventional steel B10 ....".

The technology of US '322 does not disclose, suggest or contemplate a "bainite index" on the order of a negative number of approximately -2496% which is the result of the present invention.

<u>Cooling Rate R</u>

When the steel of US '322 contains Mo, the maximum "cooling rate R" of US '322 is defined by the equation at Col. 5, lines 18-23 wherein "maximum cooling rate R" (wherein R is °C/min; see Col. 4, line 40 and Examples of US '322) is defined as:

$$R \leq 762 - 502C + 103Si - 115Mn - 139Cr - 31Ni - 151Mo.$$

For simplicity of comparison, assume maximum 0.7% Si and minimum 1.0% Cr and minimum 1.0% Mn of US '322 were employed (see Col. 4, lines 28-29).

+ 103 (0.7%Si) = + 72.1

- 139 (1.0%Cr) = - 139

- 115 (1.0% Mn) = -115

All other components of the equation for the maximum cooling rate R "(Max R) would cause Max R to decrease.

Max R (approximate) = 762 + 72.1 - 115 - 139 °C/min

Max R (approximate) = 580.1 °C/min

The Max R (approximate) of US '322 is 580.1°C/min. (The actual Max R of US '322 would be lower than 580.1°C/min). This approximate <u>maximum cooling rate R</u> of 580.1°C/min of US '322 is totally unrelated to the <u>minimum cooling rate</u> of 6,000°C/min of the present invention. The <u>minimum cooling rate</u> of the present invention is more than <u>10 times greater</u> than the <u>maximum cooling rate</u> of US '322.

Summary

US '322 is not using the term "water quenching" in places such as Col. 9, lines 53-56 in its ordinary and accustomed meaning as understood by one skilled in the art. The US '322 "water quenching" at Col. 9, lines 53-56 must comply with the "banite index" or "cooling rate R" of US '322. When US '322 distinguishes the technology of US '322 from the practice of "water quenching" such as at Col. 6, lines 40-44, the distinguished practice of "water quenching" is use of the term in its ordinary and accustomed meaning as understood by one skilled in the art.

Cited Tables - US '322

The Office Action at page 6 cites Tables 1 and 2 of US '322 with respect to steels B1 (1726 MPa), B6 (1794.7 MPa) and B8 (1814.3 MPa).

With reference to Table 1, steel B1 contains 2.38% Cr; steel B6 contains 1.55 % Cr and steel B8 contains 1.95% Cr. The steel compositions of steels B1, B6 and B8 are very different than the maximum 0.5% Cr in accordance with the present invention. Steel B8 contains 1.92% Mn which is greater than the maximum 1.60% Mn in accordance with the present invention. With reference to Table 2, steels B1, B6 and B8 all have cooling rates expressed by °C/<u>min</u> of not more than 115°C/<u>min</u>. This is <u>air cooling</u>. Water quenching is cooling at a cooling rate of 6,000°C/<u>min</u> (100°C/<u>sec</u>) or greater.

Steels B1, B6 and B8 of US '322 are very different than the steel pipe in accordance with the present invention.

The Office Action at page 7 cites Tables 1 and 2 (should be Table 3) with respect to steel B10 (2059.47 MPa).

With reference to Table 1, steel B10 contains 2.97% Mn and 1.02% Cr. The steel composition of steel B10 is very different than the maximum 1.60 % Mn and the maximum 0.5% Cr in accordance with the present invention. Note that steel B10 also contains 0.48% C and 0.64% Si. The steel composition of the present invention contains a maximum of 0.30% C and a maximum of 0.27% Si. The steel composition of steel B10 of US '322 is unrelated to the steel composition of the present invention. With reference to Table 3, steel B10 has a cooling rate of 265 °C/<u>min</u>. This again is <u>air cooling</u>.

Steel B10 of US '322 is very different than the steel pipe according to the present invention.

<u>Cr Essential</u>

US '322 discloses a steel member having a composition containing 1.0 to 3.5% Cr as an <u>essential</u> component. US '322 discloses 1.0 to 3.5% to Cr at Col. 4, line 29, Col. 6, lines 40-50, and independent claims 1 and 4. In addition, all steel types of the

examples of US '322 in Table 1 at Cols. 11-12 of US '322 disclose more than 1.0% Cr except steel type A13. Steel type A13 is identified as conventional steel (not the steel of the technology of US '322) which contains 0.68% Cr (greater than 0.5 Cr) and 1.86% Mn (greater than 1.60% Mn). The specification of US '322 states at Col. 6, lines 40-44:

> Cr is essential to the present invention in which a long pipe is quenched by cooling at a cooling rate corresponding to that of air cooling with distortions caused by quenching being greatly suppressed compared with those caused by water quenching.

In the present invention, Cr is an arbitrary component of the steel pipe composition, and if Cr is present in the composition of the steel pipe, the present invention limits the Cr content to not more than 0.5%. That is, the minimum essential Cr of US '322 (1.0% Cr) is twice as much as the maximum optional or arbitrary Cr (0.5%) permitted by the present invention.

Air Cooling

As noted above, US '322 at Col. 6, lines 40-44 clearly teaches air cooling and clearly teaches against water quenching. The essential Cr of US '322 is directly linked by the disclosure of US '322 to the cooling of a heat treated pipe by a cooling rate in a range provided by air cooling.

In contrast, the heat treated steel pipe of the present invention is water quenched, as defined in the claims. Water quenching of the present invention is directly related to the very high tensile strength (TS) and low yield rate (YR) of the present invention. The water quenching of the present invention results in the very high dislocation density of the present invention, 10^{10} to $10^{14}/mm^{-2}$, which results in the very high tensile strength (TS) of the present invention.

US ‘322 teaches air cooling and teaches against water quenching throughout the specification of US ‘322. For example, US ‘322 states at Col. 1, lines 11-15:

> Instead of quenching following finish forming, normalizing can be applied to the steel member of this invention so as to achieve high strength and improved toughness, and therefore quenching distortion does not occur.

Normalizing is air cooling. The technology of US ‘322 is directed to air cooling and not water quenching.

US ‘322 further states at Col. 3, lines 38-57:

> It has been thought that it is advantageous to employ an as-quenched material in order to provide a steel member with a high strength at low costs. For this purpose it has been known to utilize water-quenching followed by tempering at a temperature as low as 200°C or less. However, water-quenching results in relatively large distortions which must be recovered at a later state. Furthermore, when the strength of the steel member is high, cracking and buckling, for example, occur with a degregation in accuracy in size during recovery of the distortions, making the recovery rather difficult from a practical viewpoint. Thus, from a practical viewpoint it is desirable that quenching be carried out by air cooling.
>
> According to the findings of the present inventors, it is possible to carry out quenching by air cooling when a steel composition is adjusted to a suitable one, particularly when the banite index is restricted to 0-50% and a steel member having a high strength and toughness with a low yield ratio can be obtained.

Col. 8, lines 8-9 of US ‘322 states that the steps within box in Fig. 1 are essential steps to the invention of US ‘322. Fig. 1 of US ‘322 disclose “Air Hardening” in a box. Thus, air cooling is taught as essential to the technology of US ‘322.

The maximum cooling rate actually used in the Examples of US ‘322 is at Table 5, Steel Type B10, cooling rate R = 300°C/min and Table 7, Steel Type B10, cooling rate R = 300°C/min. The maximum calculated cooling rate in the Examples of US ‘322 is at

Table 3, Steel Type A10, and Table 5, Steel Type A10, calculate maximum cooling rate R = 498°C/min. Note: These examples are identified as "conventional".

The present invention employs a water quenching cooling rate of 6,000°C/min (100°C/sec) or higher. See specification page 9, line 37 to page 10, line 3. The water quenching of the present invention is essentially for achieving the very high tensile strength (TS) of the present invention. This has been previously discussed in detail. See specification page 9, line 14 to page 10, line 9. Table 2 at page 14 of the specification disclose cooling rates for the Inventive Examples of the present invention ranging between 150 to 200°C/sec (9,000 to 12,000°C/min).

US '322 clearly teaches air cooling of a heat treated steel pipe and clearly teaches away from water quenching of heat treated steel pipes. The cooling rates disclosed in US '322, in the parameter °C/min, are not comparable to the water quenching cooling rates, 6,000°C/min or higher, used in the present invention.

The water quenching of the present invention, as defined in the claims, is required to achieve the very high tensile strength (TS) in combination with low yield ratio (YR) using the steel composition in accordance with the present invention.

Examples of US '322 - Tensile Strength

The examples of US '322 clearly show that US '322 cannot achieve a tensile strength (TS) of 173.9 kgf/mm^2 or greater (1700 MPa or greater) with a steel pipe having a composition as defined in independent claims 1 to 4 and 17.

The compositions of the steel pipes used in the examples of US '322 are listed in Table 1 of US '322. Note that all examples of US '322 disclose air cooling.

The following is a listing of steel pipes of US '322 having a tensile strength (TS) of 173.9 kgf/mm^2 or greater along with the composition of the steel pipe. The steel pipes are identified by Table number and "Steel Type".

TABLE 2 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
Al	177	2.66	1.08	-	
BI	176	1.09	2.38	-	See C & Si
A4	186	1.53	1.89	-	
A4	205	1.53	1.89	-	
B6	183	1.35	1.55	-	
B8	185	1.92	1.95	-	

TABLE 3 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B10	210	2.97	1.02	-	See C & Si
A12	176	1.03	1.01	1.76	

TABLE 4 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B1	181	1.09	2.38	-	See C & Si
A4	182	1.53	1.89	-	
B6	177	1.35	1.55	-	
B8	180	1.92	1.95	-	
A9	174	1.62	1.54	-	

TABLE 5 of US '322

Steel Type	TS	Mn	Cr	Mo	Note

B10	207	2.97	1.02	-	See C & Si
A12	193	1.03	1.01	1.76	
B1	189	1.09	2.38	-	See C & Si

TABLE 6 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B1	178	1.09	2.38	-	See C & Si
A4	183	1.53	1.89	-	
B6	178	1.35	1.55	-	
B8	181	1.92	1.95	-	

TABLE 7 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B10	208	2.97	1.02	-	See C & Si
A12	176	1.03	1.01	1.76	

It is readily apparent that any example of US '322 that has a tensile strength (TS) of 173.9 kgf/mm^2 or greater has a composition that is outside the composition of the steel pipe of the present invention as defined in independent claims 1 to 4.

US '322 does not disclose or suggest the steel composition of the present invention. US '322 teaches that 1.0 to 3.5% Cr is essential in the steel composition. In the present invention, Cr is an arbitrary component in the steel composition, and if present, Cr is limited to not more than 0.5%.

US '322 teaches air cooling and teaches against water cooling. All the Examples of US '322 disclose air cooling. In the present invention, water quenching is required to achieve the very high dislocation density of 10^{10} to10^{14}/mm^{-2}. As previously

discussed in detail, the very high dislocation density of the present invention is directly related to the very high tensile (TS) and low yield ratio (YR).

US '322 does not disclose or suggest a <u>water quenched</u> steel pipe having the composition defined in independent claims 1 to 4 and having a tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) or greater. US '322 does not disclose or suggest how to make a steel pipe with the steel composition defined in independent claims 1 to 4 having a tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) or greater because US '322 does not disclose or suggest water quenching of a heat treated steel pipe having a steel composition in accordance with the present invention. US '322 teaches air cooling a heat treated steel pipe which does not have the defined steel composition of the present invention.

US '322 does not disclose or suggest the very high dislocation density of 10^{10} to $10^{14}/mm^{-2}$ of dependent claim 6. The very high dislocation density of the present invention is the result of water quenching and the very high dislocation density of the present invention results in the very high tensile strength (TS) and low yield ratio (YR) of the present invention. US '322 teaches air cooling of a heat treated steel pipe and teaches away from water quenching.

SUMMARY OF PATENTABILITY

In view of the reasons set forth in the foregoing, it is submitted that amended independent claims 1 to 4, and all claims dependent thereon, are patentable over Japan No. 6-179945. JP '945 does not disclose or suggest a water quenched steel pipe having the claimed composition in <u>combination</u> with the claimed tensile strength (TS) of amended independent claims 1 to 4.

In view of the reasons set forth in the foregoing, it is submitted that amended independent claims 1 to 4, and all claims dependent thereon, are patentable over U.S. Patent

No. 5,374,322 to Okada et al. US '322 does not disclose or suggest a water quenched steel pipe having the claimed composition in combination with the claimed tensile strength (TS) of amended independent claims 1 to 4.

Dependent claim 6 is further patentable because neither JP '945 nor US '322 disclose or suggest the high dislocation density of 10^{10} to $10^{14}/mm^{-2}$ of dependent claim 6. The high dislocation density of dependent claim 6 is the result of water quenching and is directly related to the high tensile strength (TS) of the present invention. JP '945 and US '322 teach air cooling.

CONCLUSION

In view of the present amendment, and the foregoing remarks, it is submitted that the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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